TEXTILE BROADBAND E-PATCH ANTENNA AT ISM BAND

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Abstract: A textile E-shaped patch antenna for communications in the ISM band (2.4 GHz - 2.5 GHz) is presented. Design was inspired from literature and further tuned using in-house FDTD software. The textile antenna compares reasonably well with the same antenna in conventional technology offering a wide bandwidth of 17% around 2.4 GHz and good radiation patterns.

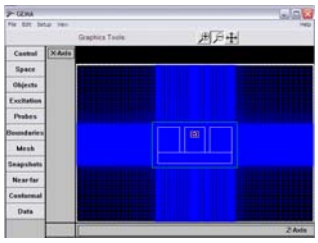
Motivation

- Growing demand for wearable computers from military, medical and commercial sectors
- Antennas will play a central role for wearable applications and need to be light and comfortable to wear
- Some textile antennas have appeared recently in the literature
- Most prototypes are narrow-band and can easily get detuned by the curvature or the presence of the body when worn
- An antenna with a good match around the centre frequency and a wide bandwidth is therefore desirable to overcome these drawbacks

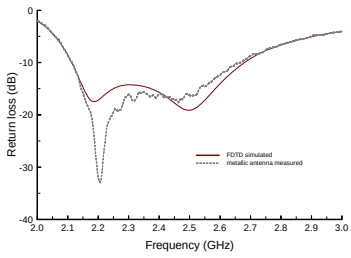
The metallic E-shaped patch antenna

The conventional metallic antenna C_1 used for reference consists of a patch in the shape of the letter E made in brass and suspended in air above an aluminium ground plane.
Initial design was based on dimensions specified in [1], a substrate thickness of 9 mm being considered so that two layers of fleece would subsequently take the place of the air substrate exactly.

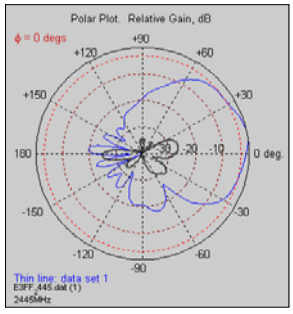
Classical metallic E-shaped antenna



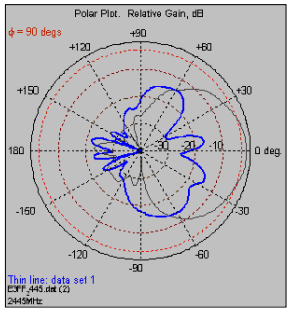
FDTD model of the antenna



Return loss for the metallic antenna C1



E plane



H plane

Radiation patterns for the metallic antenna C_1

The metallic antenna C_1 has wideband characteristics in excellent agreement with FDTD predictions showing a 23% bandwidth centred on 2.4 GHz. Measured radiation patterns exhibit cross polarisation levels which are low in the E plane and somewhat larger in the H plane (in agreement with the observations in [1]). This feature may be prohibitive for some applications but still acceptable for others. The antenna was shown to be not too sensitive to manufacturing tolerances.

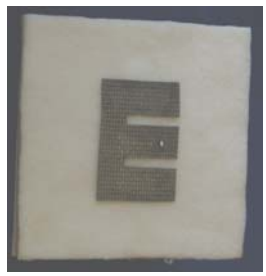
[1] F. Yang, X.-X. Zhang, Y. Rahmat-Samii, "Wide-Band E-Shaped Patch Antennas for Wireless Communications", *IEEE Trans. on Antennas and Propagation,* Volume 49, No. 7, pp. 1094-1100, July 2001

The textile E-shaped patch antennas

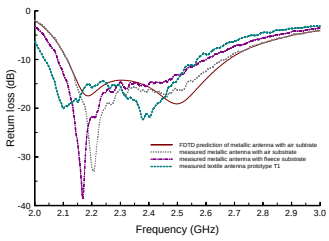
Various textile E-shaped antennas were fabricated at Bristol:
- T_1 of the same dimensions as C_1
- T_2 and T_3 with optimised dimensions

All prototypes use the same highly conductive fabric for the E patch and for the ground plane with a commonly available fleece fabric in between. Conductive fabric is *Nora* for T_1 and T_2 and *Nice* for T_3, both fabricated by Shieldex and offering an average shielding effectiveness of 80 dB in the ISM band.

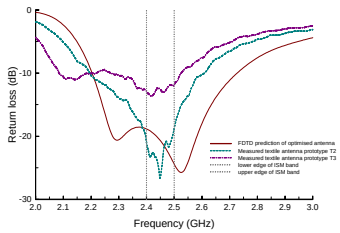
Textile E-shaped antenna with *Nora*



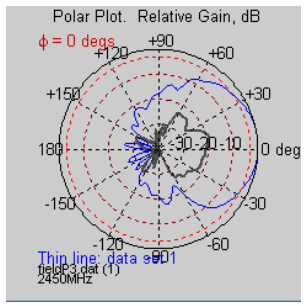
Textile E-shaped antenna with *Nice*



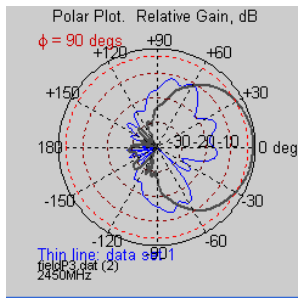
Measured return loss for textile antenna T_1 and metallic antenna with fleece substrate inserted



Measured return loss for textile antennas T_2 and T_3 along with simulated FDTD of optimised antenna



E plane



H plane

Radiation patterns for the textile antenna T_3

- Manufactured textile antenna T_1 has nice wideband behaviour with 23% bandwidth and in band match around -15 dB. However, its centre frequency is shifted down by 0.1 GHz and the ISM band is just about covered. This is partly due to the permittivity of the fleece layer not taken into account in the model.
- Optimised textile antennas T_2 and T_3 also show some variation with the predicted FDTD response but the ISM band is covered in both cases.
- The *Nice* fabric was found to absorb epoxy glue far more than the *Nora* fabric and this is believed to produce a slightly blurred and lower frequency response for prototype T_3
- Textile prototype T_2 presents an in band match below -20 dB in the ISM band of interest and exhibits a wideband behaviour with 17.22% bandwidth centred on 2.40 GHz
- All three textile prototypes were found to have radiation patterns with similar appearance that compare well with those obtained for the metallic antenna

Conclusions

- Although the fabrication process should be refined for repeatability, all textile prototypes covered the ISM band of interest, the *Nora* antennas giving wideband performance such as a 17% bandwidth centred on 2.4 GHz and good in band match below -20 dB.
- The radiation patterns for all textile antennas were similarly good and compared well with those for the conventional metallic antenna.